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Title: Implications of Confirmation of the LSND Muon Anti-Neutrino to Electron Anti-Neutrino Oscillation Signal (U)

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Los Alamos NATIONAL LABORATORY

NuFact 2004 Talk Abstract : Probing Mechanisms for Oscillations Post-MiniBooNE

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An oscillation signal seen by MiniBooNE will validate the accelerator neutrino oscillation signal first seen by the LSND experiment. However, the mechanism for these oscillations will still remain a mystery. The question then becomes how to determine what causes oscillations. Three possible mechanisms for oscillations are the existence of sterile neutrinos, CPT violation, and the existence of variable mass neutrinos. The Spallation Neutron Source (SNS), located at Oak Ridge Laboratories, Oak Ridge, Tennessee, will provide an ideal site to test these three hypotheses. The SNS, due to turn on in 2008, will supply a high intensity neutrino source of known flux and energy spectrum. This source permits experiments to probe the high Δm^2 region for measurements, in the region where a positive signal from MiniBooNE would lie. This talk will focus on the properties of SNS and possible experiments which would probe the mechanism for neutrino oscillations which occur at high Δm^2.

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Implications of Confirmation of the LSND $\overline{\nu_\mu} \rightarrow \overline{\nu_e}$ Oscillation Signal

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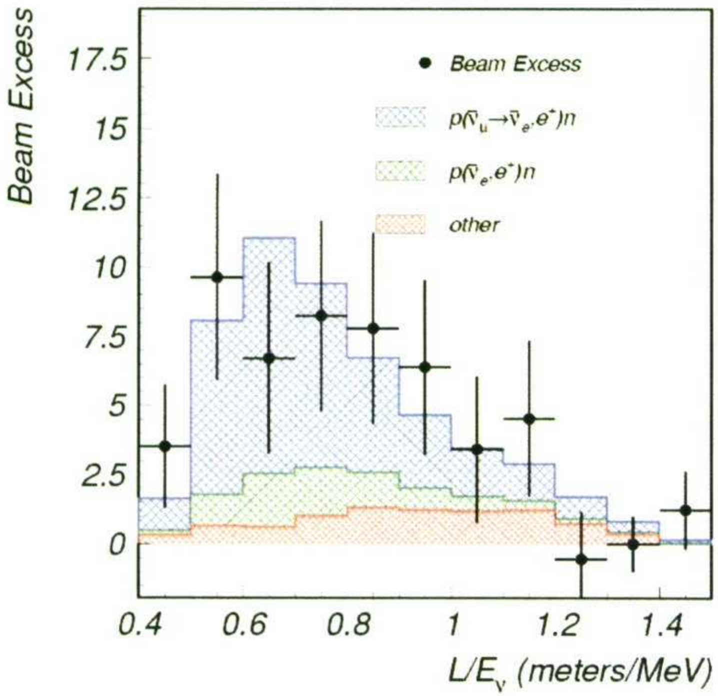
Current Oscillation Status

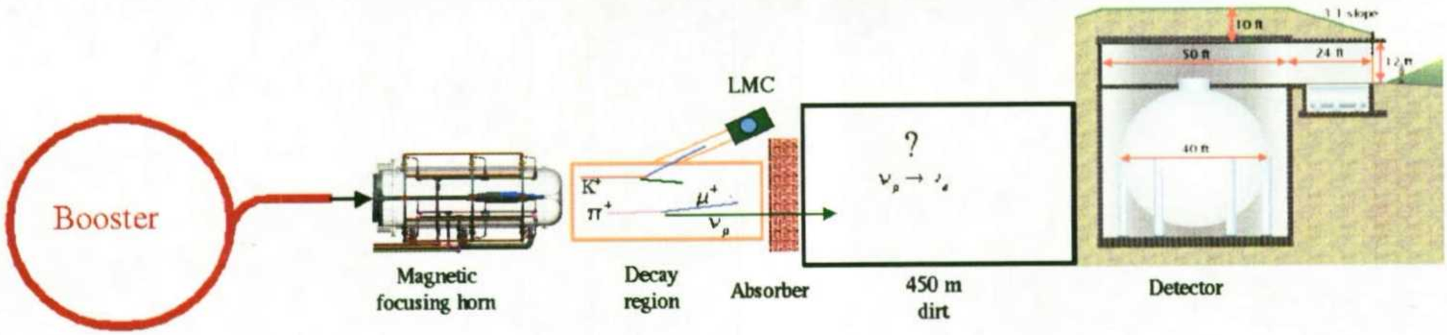
- Solar ν
  - Deficit of ν_e from $\odot$
  - $\triangle \mathrm{m}^2 \approx 7 * 10^{-5} \mathrm{eV}^2$
- Atmospheric ν
  - Zenith angle deficit of ν_μ
  - $\triangle \mathrm{m}^2 \approx 2 * 10^{-3} \mathrm{eV}^2$
- LSND Accelerator ν
  - Excess of $\overline{\nu_e}$ in $\overline{\nu_\mu}$ bean from μ^+
  - $\triangle \mathrm{m}^2 \approx 0.1 \rightarrow 10\ \mathrm{eV}^2$

LSND

- 800 MeV proton beam, water target, ν_μ from $\pi^+ \rightarrow \mu^+$
- Liquid scintilliator, PMTs
- $E_\nu \sim$ 20 - 53 MeV, L $\sim$ 25 - 35 m

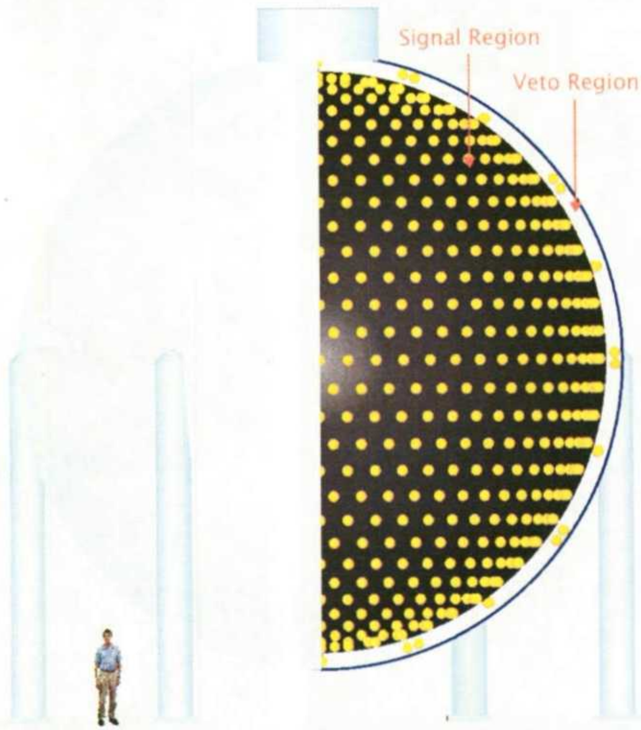


MiniBooNE



- 8 GeV proton beam, Be target, ν_μ from $\pi^- \to \mu^-$
- Non-scintillating oil
- $E_\nu \sim$ 750 - 800 MeV, L $\sim$ 500 m

MiniBooNE Detector

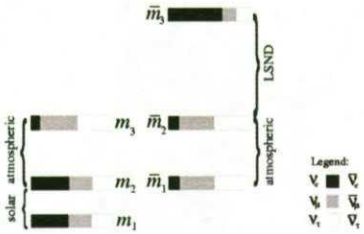


MiniBooNE vs LSND

- MiniBooNE : higher Energy
- Differences in ν source
- Differences in backgrounds
- Duty Factor lower at FNAL (reduces cosmics)
- MiniBooNE : higher statistics

Physics of Positive LSND

- Sterile νs
  - Weak isospin singlets - high mass states (LSND) mostly sterile ν
  - *hep-ph 0403158, Cirelli, Marandella, Strumia, Vissani*
- Mass Varying νs
  - Mass depends on medium
  - *hep-ph 0401099, Kaplan, Nelson, Weiner, hep-ph 0405141, Zurek*
- Lorentz Violation
  - ν oscillations explained by small Lorentz violation $\rightarrow$ oscillations in LSND but not CHOOZ explained
  - *hep-ph 0406255, Kostelecky, Mewes*
- CPT Violation
  - Allow $\triangle \mathrm{m}_{\bar{\nu}}^2 > \triangle \mathrm{m}_{\nu}^2$, 3 SM ν model
  - *hep-ph 0402005, Mavromatos*

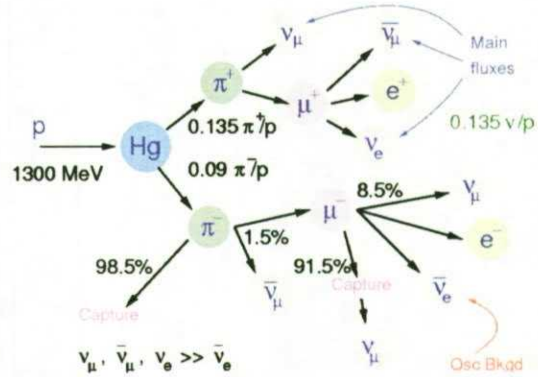


Tests of NP : MiniBooNE

- Sterile νs
  - Second detector (BooNE), measure NC cross section
- Mass Varying νs
  - If measure oscillation in 0.1 $\mathrm{eV}^2 < \Delta \mathrm{m}^2 < 0.25\mathrm{eV}^2$ (BUGEY excludes)
- CPT
  - Run in $\overline{\nu}$ mode

Tests of NP : SNS

- Pulsed 1.4 MW, 1 GeV proton beam $\rightarrow$ mercury target



- Beam stop provides $\sim$ 3*10^{22} DAR ν/year from π^+ and μ^+
- Beam spill of 700 ns $\rightarrow$ good separation of ν_μ from π^+, ν_e, $\overline{\nu_\mu}$ from μ^+
- Hg absorbs most π^-, μ^-

SNS Physics

- Two detectors : one inside the Target Hall, one 60 m from target, 130 degrees to direction of proton beam
- Scintillting oil/PMT detectors
- in 1 year, can cover LSND signal

SNS vs LSND

- SNS : more statistics
- Lower DF
- Very low bgd (DAR)
- Larger detector
- higher ν flux

Tests of NP : Minos

- Sterile νs
  - NC cross section
- Mass Varying νs
  - If measure $\mathrm{Sin}^2 2\theta_{13} >$ CHOOZ

Summary

- If LSND signal confirmed need to determine which NP model is correct
- 4 main models, can be explored with additional detector at FNAL (BooNE), SNS expt
- Exciting time to be in neutrino physics